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Determining appropriate feed-in tariff rates to promote biomass-to-electricity generation in Eastern Ontario, Canada

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HIGHLIGHTS

- Economic performance of biomass-to-electricity generation in Ontario is assessed.
- Feed-in tariffs needed to meet industrial payback and IRR targets are determined.
- Existing feed-in tariff rates for biomass must be raised to meet industrial targets.
- Incentives that adjust feedstock price might be explored to increase biomass use.

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ABSTRACT

On-site data collection, interviews, and financial models were used to determine the feed-in tariff (FIT) rate required to encourage investment in the generation of electricity from currently unused biomass from the Eastern Ontario forest industry. A financial model was adapted and run to determine the net present value, internal rate of return, and payback period associated with a 15 MW biomass-to-electricity facility. The analysis suggests that Ontario should consider a stronger incentive than the recently-offered CDN$ 0.13 $kW^{-1}\,h^{-1}$ for biomass-to-electricity. If no customer for heat generated from the plant can be found, FIT rates between CDN$ 0.17–0.22 $kW^{-1}\,h^{-1}$ are necessary to achieve a 15% internal rate of return and a simple payback of approximately 5 yr; achieving a price of CDN$ 0.013 kW^{-1} of thermal output still requires elevated FIT rates between CDN$ 0.15–0.21 $kW^{-1}\,h^{-1}$ to meet economic performance criteria. Other barriers, particularly regulations regarding the use of operating engineers in steam plants, should also be addressed to facilitate development of biomass-to-electricity. Without these changes, it is likely that biomass will be significantly under-used and will not contribute to the renewable energy goals of Ontario.

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1. Introduction

The Canadian province of Ontario has recently created two important pieces of policy to help guide future development of electricity generation capacity. The first was the Green Energy and Green Economy Act (GEGEA) of 2009, which created a feed-in tariff (FIT) program to provide incentives for renewable electricity generation via biomass, biogas, wind and solar technologies (Ontario, 2009). The FIT program was canceled in June of 2013 and replaced with a bidding system (Gipe, 2013); however, the pricing structure used in the FIT will likely set the baseline for future project bids. The second policy, released by the Ontario government on November 23, 2010, was an updated Long-Term Energy Plan that defined the role of fossil, nuclear, and renewable electricity in the province (OPA, 2010). This plan has recommended creating a balanced mix of clean power sources and increasing Ontario's power supply from renewable sources such as wind, solar, and bio-energy to 13% by 2018, up from the current level of 3% (OPA, 2010). Taken together, these policies set the course for a cleaner electricity generation portfolio in the province that addresses emission reduction, industrial development, and employment goals.

Incentives that increase the production of renewable power could provide support to other struggling sectors in the province. For example, Ontario's forest sector has been hit hard by the combined effects of a declining market for pulp and paper products and a much reduced housing market in the United States, both of which have diminished demand for Canadian lumber

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products. In the past decade, 11 of 16 pulp and paper facilities across the province have shut down (Mabee and Mirck, 2011). At the same time, the percentage of land being harvested of total available forest has declined and is currently about 9 million m^3 less than the total estimated to be available under the annual allowable cut (Ontario MNR, 2006).

Bioenergy technologies, specifically those that facilitate wood-to-energy platforms, represent renewable energy alternatives that can support the province's forest sector. The Canadian forest industry has actively explored bioenergy production as a partial solution to the decline in traditional products; new technologies could create new markets and allow provinces and industry to utilize excess forest feedstocks before they succumb to pests or fire. The most prominent work exploring this area is the Biopathways Project, led by the Forest Products Association of Canada (FPAC) with input from industry (FPInnovations), government (Natural Resources Canada), and academia (FPAC, 2011). The Biopathways project considered stand-alone wood-to-energy options, as well as biorefining solutions that can deliver combinations of heat, electricity, liquid fuel, and chemicals. Development of forest-based biorefineries has been underway for years, although commercial implementation of these technologies in their full complexity remains elusive (see Sims et al., 2010).

In Ontario, the FIT rates were varied by technology. Under the most recent FIT schedule, these rates ranged from CDN$ 0.103 $kW^{-1}\,h^{-1}$ for electricity from landfill gas to as high as CDN$ 0.549 $kW^{-1}\,h^{-1}$ for electricity from rooftop solar panels (Mabee et al., 2012; OPA, 2012). Forest biomass-to-electricity options were offered between CDN$ 0.13 and 0.138 $kW^{-1}\,h^{-1}$, which is considerably less than what was offered for solar power but priced similarly to wind and hydropower technologies, reflecting in part the perceived maturity and different costs of these options.

In this study, the capital cost of a biomass-to-electricity plant is estimated at approximately CDN $3.8 million MW^{-1} installed (see Discussion). By comparison, a wind farm built in Eastern Ontario in 2009 cost approximately CDN $2 million MW^{-1} (Journal of Commerce, 2009), while a solar farm built around the same time cost about CDN $6.7 million MW^{-1} (CBC, 2010). It should be noted that the intermittent nature of wind and solar power means that the net present values (NPVs) of hypothetical 10 MW solar and biomass contracts under the Ontario FIT are similar (approximately CDN$77 million), while the estimated NPV of a 10 MW wind project is significantly lower (approximately CDN$37 million) (Mabee et al., 2012). Despite having lower capital costs, biomass plants have proven less popular than solar in Ontario. Only 23 biomass-to-electricity projects were active as of March 2013, with capacity of 18.7 MW, compared to a total of 583 solar projects with capacity of 173 MW (OPA, 2013). The preference for solar power is likely because the operating costs for solar (and wind) plants do not include feedstock costs, which are significant for biomass-to-electricity facilities (as explored later in this paper). Wind power has significantly lower capital costs and attractive returns and has been the most popular option under Ontario's FIT program, with capacity of 280 MW from nine projects completed as of March 2013 (OPA, 2013). It is important to note that, unlike jurisdictions such as Germany, Ontario does not offer FIT rate bonuses for the production of heat – the provincial model only provides incentives for electricity, which further discourages investment in biomass facilities (Mabee et al., 2012).

Renfrew County is located in the central part of Ontario, stretching almost 100 km along the Ottawa River valley from Arnprior (north of the City of Ottawa) to the northern end of Algonquin Provincial Park. It is heavily forested and employment in the forest sector has traditionally been strong. Encouraged by the potential for bioenergy to help reduce or reverse job losses in the forest sector, the Renfrew County Community Futures Development Corporation (RCCFDC) approached the Monieson Centre at Queen's University to conduct a preliminary feasibility study on energy generation from biomass under the Ontario Feed-In Tariff (FIT) program. The RCCFDC is a community-based non-profit organization that is dedicated to creating opportunities for entrepreneurship and the pursuit of economic growth in Renfrew County. The Monieson Centre connects organizations and researchers to provide real-world solutions that are evidence-based and comprehensive to business, industry, and communities.

The assumption put forward by the RCCFDC is that the feed-in tariff recently offered for wood-to-electricity in Ontario was too low. This has been reported to the County by industrial proponents interested in creating generating capacity, who would naturally be favorable to higher power incentives. The study team felt that this assumption deserved to be tested, and perhaps to answer why only 12% of the projects currently in development under the recent FIT are bioenergy projects, while 68% of the uptake is for wind power projects that are offered approximately the same tariff (Mabee et al., 2012). Development of biomass-to-electricity pathways is particularly important in that these power sources are dispatchable; in other words, they can be turned on and off as demand dictates, unlike wind and solar power. Biomass-to-electricity development would thus serve to increase the utility of Ontario's renewable power portfolio (Mabee et al., 2012). The RCCFDC reported to the research team that potential operators of biomass plants in Renfrew County estimated a break-even FIT rate of CDN$ 0.19–0.20 $kW^{-1}\,h^{-1}$ to meet the costs of wood supply and plant construction and operation.

It should be noted that increasing FIT rates are not the only way that a biomass-to-electricity operation might break even; tools such as carbon pricing might also provide significant revenue based on current understanding of comparative life cycle emissions from different renewable sources (see Osmani et al., 2013). In this paper, however, potential revenues based on these sources are not considered, as the focus remains on the feed-in tariff tool.

2. Methodology

A financial model originally developed by an Ontario-based engineering firm (CEM Engineering) was selected as the most appropriate tool for evaluating wood-to-electricity technologies (model communicated by Lensink, 2011). Other public-domain models were considered for the project, including RetScreen International Model developed by the government of Canada (NRCan, 2011). Unlike the RetScreen model, the CEM Engineering model included the escalation factor included in Ontario's recent FIT program (for discussion see Mabee et al., 2012) and was capable of including a value for heat produced from the facility, and thus this model was ultimately selected for the research. Data gathering and verification were carried out by the research team via interviews with forestry companies and sawmill operators in Renfrew County, as well as the management at Nylene Canada, a chemical company that has been in operation in Arnprior, Ontario since 1966 and which is one of the most diverse polymer manufacturing plants in the province (Nylene, 2011). Nylene could be an interesting partner in a wood-to-electricity project. In the short term their plant requires a great deal of steam, which makes them a possible candidate for a cogeneration program. In the longer term, a chemical company is a potential biorefinery partner.

2.1. Site visits

The research team attended meetings and interviewed individuals and companies across Renfrew County. Prior to these interviews, the research team identified candidates and sent them each a copy of the questionnaire. The groups approached in the interview process included members of the existing forest industry: David Stewart, Leo Hall (Opeongo Forest, based in Renfrew, Ontario), Herb Shaw & Sons Ltd. (Pembroke, Ontario), Ben Hokum & Son Ltd. (Killaloe, Ontario), and Barry Verch (M.W. Miller Logging, based in Eganville, Ontario). These individuals and their companies offered valuable assistance during this visit to Renfrew County by taking time from their busy schedules to discuss the Renfrew biomass project and to tour nearby logging operations. Courtesy of these parties, the research team was able to view a mechanical harvesting system to get a better sense of the stages of biomass harvest, transport, and processing. These visits and interviews were used in developing a financial model/case to determine the most appropriate FIT rate for biomass electricity production.

Interviewees also included industry interested wood-to-energy development, such as the Ontario Biomass Energy Alliance (OBEA), Alastair Baird (Manager of Business and Economic Development at the County of Renfrew), David Stewart and Diane McKinnon (RCCFDC), and David Steeds (Nylene Canada Inc., Arnprior, Ontario). Members of this group pointed out the need for Operating Engineers for any biomass plant under consideration, referencing Ontario Regulation 219/01 (Ontario, 2001) that lays out the requirements for operators of boilers in Ontario. According to our interviewees, this requirement may be a regulatory and financial challenge to the ability to operate biomass electrical generation facilities. Other jurisdictions have recognized this challenge; the British Columbia government, for example, has updated their requirements and no longer requires low-pressure thermal fluid or steam plants to have an engineer on staff 24 h per day, seven days per week. The new BC rule generally exempts non-pressurized plants of any size from the staffing requirement if they have automated control systems, commissioning systems, functional testing programs, and maintenance programs that have been approved by a professional engineer, according to the BC Safety Authority (BCSA, 2011). Making this change has allowed state-of-the-art biomass boilers to be employed within the province (BCSA, 2010). The British Columbia example could serve as a template for modifying the Ontario regulation.

During these interviews, the local situation was described in detail by participants in the study, with particular emphasis placed on the closure of pulp mills and panel operations and the subsequent loss of local jobs. Without the income from the sale of forest residue and low-end products, the normal logging operations are not profitable enough to continue for the long term (see Mabee and Mirck, 2011). Common topics raised in the interviews included a frank discussion of costs, availability, modes of transportation, various uses for the wood products, government restrictions, and possible scenarios for modifying Ontario's FIT program.

2.2. Renfrew County sawmills

Most wood contains up to 50% moisture when cut – in other words, the ratio of wood-to-water on a weight–weight basis is 1:1 (see Panshin and de Zeeuw, 1980). If the harvested and piled wood is left to dry for several months at the roadside, moisture content typically decreases to 30–40% (Hall, 2011), which would still be referred to as 'wet' or green wood. Moisture content is a key consideration, as transporting water within green wood means moving mass that has no material or energy value. Because the load limit on Ontario's highways is 36–38 t per load, a tractor-trailer load with a moisture content of 30–50% is equivalent to 18–25 oven-dried tonnes. Sawmills in Renfrew County reported average net income rates of between CDN$ 18 and 35 per green tonne delivered, depending on the species of biomass. This rate essentially subtracts the cost of delivered wood to the mill gate from the value of the timber products the sawmill produces. Residual wood – the material that cannot be sold for profit – makes up a variable component of the total.

Large mill operations can utilize "hog fuel" – residual wood left in large chunks – as feedstock for large boilers. These boilers can be used to generate steam, which acts as a heat source for lumber kilns or for mill buildings (Islam et al., 2004). Smaller mill operations, with relatively low heat demand, may have an opportunity to operate a "package boiler" on site. These boilers cannot handle large chunks of wood, so implementing this solution would involve chipping residual wood (using a facility such as a hammermill). Hoppers or silos can be installed to store processed wood for boilers. Some have proposed using pelletization (Chau et al., 2009) or torrefaction (i.e., subjecting wood to mild pyrolysis at 200–300 °C); (Chew and Doshi, 2011) to increase the energy density and handling properties of wood, making it easier to store significant amounts. Using a cogeneration package boiler, wood chips, pellets or torrefied material could be burned to provide both heat for use on-site, as well as electricity that could be sold to the grid under the FIT program.

2.3. Model parameters employed

2.3.1. Nominal capacity

The hypothetical plant will have the nominal capacity to generate 15,000 kW of electricity at maximum output.

2.3.2. Maximum system operation

At the ideal maximum, the system will operate 8000 h yr^{-1}; this would allow for two scheduled shutdown periods of two weeks each, as well as another four days of unplanned shutdowns or holiday.

2.3.3. Gross system heat rate

As a combined heat and power facility, a gross system heat rate (i.e. the amount of heat generated per unit of electricity generation) was set at 2.64 kW of thermal energy (kWth) for every 1 kW electricity. The ratio of electricity to heat in this model is 38%; typically, combined heat and power facilities have electricity generation rates that range between 30% and 50% of thermal capacity (see IEA, 2012).

2.3.4. Average plant heat use

The model assumes that the plant uses an average of 45,000 lbs of steam per hour provided from the process itself, which is equivalent to approximately 12,240 kWth h^{-1}.

2.3.5. Capacity factor

Capacity factor is the measure of effective power production (essentially the overlap between periods of electricity demand and the availability of power generation capacity). The study uses two capacity factors for biomass-to-electricity, 60% and 85%. The lower factor is based on Ontario's Independent Electricity System Operator (IESO) data for existing biomass-to-electricity projects in the province, as well as similar factors reported in Germany (IESO, 2011; BMU, 2011). It is assumed that with 'smart grid' technology and better forecasting of demand requirements that biomass-to-electricity projects can be used more effectively (Clastres, 2011), and so a second capacity factor of 85% was also modeled. A capacity factor of 85% allows for two scheduled shut downs of two weeks per year, as well as unscheduled shut downs totaling an additional two weeks per year.

2.3.6. Capital cost (supply, install, and commission)

Capital costs rates were taken from the CEM Engineering model employed in this study. At 15,000 kW of nominal capacity, the expected total capital costs were approximately CDN$ 57.8 million.

2.3.7. Fixed operating and maintenance expenses

The fixed operating and maintenance expenses were assumed at a rate of CDN$ 150 kW^{-1} yr^{-1}, or approximately CDN$ 2.25 million per year.

2.3.8. Variable operating and maintenance expenses

These costs were assumed at a rate of CDN$ 0.09 kW^{-1} h^{-1}; at 85% capacity, these costs would be approximately CDN$ 9.2 million per year.

2.3.9. Value of natural gas displaced at the site

In March 2013, Henry Hub natural gas prices were approximately CDN$ 3.68 GJ^{-1}, or about CDN$ 0.013 $kWth^{-1}$ (EIA, 2013) (assuming exchange rates of CDN$ 0.98: USD$ 1 and 1 million BTU=0.95 GJ=263.9 kW h). Given that the plant uses an average of 12,240 kWth h^{-1}, the use of heat from the process represents a savings of about CDN $160 h^{-1} on natural gas costs.

2.3.10. Value of heat sold

At 85% capacity, given the gross system heat rate and the presumed use of a portion of thermal output within the plant, an additional 21,420 kWth h^{-1} is available for sale; at 60% capacity availability of heat drops to about 13,500 kWth h^{-1}. As has been pointed out, the most recent FIT incentive program in Ontario did not provide a bonus for heat products. Potential users of any heat/steam from a biomass-burning plant – such as a district heating grid or a large institution such as a hospital or college – are extremely limited in Renfrew, which greatly reduces the number of potential sites for a project in the County where large amounts of heat could be used effectively. In most cases, siting a plant close to a steam user would likely increase the biomass transportation costs to the plant to such an extent that it is counter-productive. The analysis considers a range of values for heat sold.

2.3.11. Biomass costs

A price of CDN$ 49.50 GT^{-1} is in line with reports from local sawmills on the price they were paid to deliver biomass to mills/plants in Quebec in 2011. The estimate is on the conservative side, since the market for biomass is currently depressed due to economic conditions, but will likely rise due to improvements in demand along with increases in transportation costs related to the price of oil.

2.3.12. Discount rate for net present value (NPV) analysis.

A discount rate of 10% was based on normal equity structure (60% debt, 40%), and is consistent with normal business practice. The expected return is influenced by the amount of interest that must be paid on debt, and the required return to provide acceptable levels of return to equity investors. A weighted average of these two (called WACC for Weighted Average Cost of Capital) forms a benchmark for evaluating new projects. Because of this, and also because of the higher return required in order to offset the risk involved with this type of venture, a higher discount rate is required compared to safer investments such as GIC's. Equity investors typically evaluate project net present value with a 10% to 15% discount rate for this type of project.

2.3.13. Depreciation: portion of project eligible for Class 43.2

This is an estimate based on the eligibility of similar projects. Class 43.1 allows taxpayers an accelerated write-off of the capital cost of certain equipment that is designed to produce energy in a more efficient way or to produce energy from alternative renewable sources. Class 43.1 allows taxpayers to deduct the cost of eligible equipment from taxable income at up to 30% per year, on a declining balance basis. Class 43.2 has been created to provide additional incentive for those systems in Class 43.1 that use fossil fuels more efficiently (efficiency=72%), for specified-waste-fuelled electrical generation systems and for renewable energy systems (small-scale hydro-electric, wind, photovoltaic, geothermal, fuel cell, and active solar) (Industry Canada, 2011).

2.3.14. Corporate income tax rate

The rate of 32% is a reasonable estimate based on current rates in Ontario.

2.3.15. Escalation rates on power sold

This is based on the Renewable Energy Standard Offer Program (RESOP), as of October 1, 2009, replaced by the Feed-In Tariff Program (FIT Program) and assumes a reasonable consumer price index (CPI) increase of 3%. For a discussion on the formula used to calculate escalation on biomass power, see Mabee et al. (2012).

2.3.16. Escalation rate on operating and maintenance (O&M) expenses

The inflation rate is set at 3% per year, which is a conservative estimate based on the trend in consumer price index (CPI) in Canada. Operating and maintenance includes wood pricing, labor cost, and fuel surcharges. This could be further broken down into the categories of Capacity Payment and Energy Payment, but there would be little effect on the payback, since O&M is a relatively small percentage of overall cost in this model.

2.4. Analysis

The capital expenditures for generating electricity from biomass are likely significantly higher than wind. With a capital cost of CDN$ 50–60 million, biomass is not a venture for very small enterprises or residential applications. This means that medium-to large-scale businesses are the only feasible owners and operators of biomass plants. This restriction to businesses must be the starting point for an analysis to determine a FIT rate that would truly encourage business investment.

Time before payback drives most of the capital investments by business, and maximum payback times are typically short. Some capital improvements or energy efficiencies must have a payback time of less than a year to be justifiable. From the interviews conducted in this study, the industry likely expects payback periods of less than 5 yr. Indeed, David Steeds, Director of Manufacturing Services at Nylene Canada, stated that in today's investment environment, Nylene would not consider a capital improvement unless the payback is 2 yr or less.

A short payback period does make sense. Although OPA signs 20 yr deals, it is apparent that political pressure can alter this over time. Indeed, in the most recent provincial election (October, 2011), the Ontario Progressive Conservative party promised to eliminate the incentive altogether as a key campaign promise (Ferguson, 2011). There is, therefore, some uncertainty about the revenue stream. There is also risk that the generation system will become obsolete or cost-ineffective as a newer method for power generation is brought on stream. So, the analysis must use payback periods as a benchmark if a biomass FIT is to encourage business investment, and those payback periods must be shorter rather than longer.

Based on those assumptions, required FIT rates can be calculated for several different payback periods by dividing the total project cost of CDN$ 57,750,000 by the average yearly net cash inflow, before interest and taxation, from the electricity generation and sale.

There are several advantages to this method. It is easy to calculate and understand, and therefore transparent to policy-makers and public alike. It is a good indicator of roughly how fast one can recover the initial cost of the project. Finally, it is realistic according to the tight timelines and near-term thinking of the owners and operators of biomass plants because the farther you go out in time, the riskier are the assumptions upon which the model is predicated.

There are two disadvantages to this approach. This calculation ignores the time-value of money, and this calculation does not account for how much revenue will be generated beyond the payback period. This is justified in this study because over the relatively short period under consideration (1–4 yr), the time-value of money is not significant given our current record-low interest rates. Also, the generation of revenue beyond the payback period is often not a consideration for an initial investment decision. (Table 1.)

2.4.1. *Impact of increasing FIT rates for electricity*

In Table 2, the impact of an increasing FIT rate about the recent $0.13 kW^{-1} h^{-1} on payback period, internal rate of return and net present value is explored. Payback period has already been described. Internal rate of return (IRR) is a commonly used measure that is used to compare the profitability of different investments; in our discussions with business owners in Renfrew, they suggested a minimal IRR of 10% but were more favorable to IRRs above 15%. Net present value (NPV) is widely used to compare the differences between inflows and outflows of cash over the course of a project; to break even, a project must have at least an NPV of CDN$ 0, but positive NPVs are usually required to initiate a project.

The analysis presented in Table 2 recognizes a value for heat used within the facility, essentially reducing the amount of natural gas purchased; however, no additional value for heat sold to other customers is included here.

Using a capacity factor of 60%, the FIT rate offered must be approximately CDN$ 0.185 kW^{-1} h^{-1} in order to generate a 20 yr IRR (after taxes, before financing) of 10% and a 20 yr NPV of CDN$ 0 (i.e., a break-even on the total investment given the discount rate of 10%). To achieve a 15% IRR and a simple payback of 5 yr, the FIT must be approximately CDN$ 0.223 kW^{-1} h^{-1}. At an 85% capacity factor, the required FIT rates are lower. A break-even project requires a FIT of CDN$ 0.146 kW^{-1} h^{-1}, while a 15% IRR and 5 yr simple payback requires a FIT of CDN$ 0.172 kW^{-1} h^{-1}. Clearly, reasonable assumptions and business considerations would dictate a biomass FIT rate above the recent OPA rate of CDN$ 0.13 kW^{-1} h^{-1}, but not to an excessive degree.

2.4.2. *Impact of increasing the value of heat sold*

In Table 3, the FIT rate is maintained at the recently-offered CDN$ 0.13 kW^{-1} h^{-1}, but an increasing value for heat sold outside of the facility (i.e., in addition to heat used inside the facility) is considered. Achieving ‘market’ value for heat (essentially equivalent to the March 2013 price for natural gas of CDN$ 0.013 kWth^{-1}) would increase the value of operations significantly, assuming that all additional heat can be sold. At 60% capacity, achieving this value would increase the IRR by 2%, decrease payback period by 1.5 yr, and raise the NPV by CDN$ 4.1 million; however, the NPV remains negative by almost CDN$ 20 million dollars. At 85% capacity, however, achieving market value for heat would reduce payback by 1.7 yr, and increase the NPV to CDN$ 1.5 million after 20 yr. In the case of 85% capacity, more additional heat is available as more biomass is combusted. In both cases, however, financial performance fails to meet the criteria of a 5 yr or less simple payback period with an IRR of

Table 1
Summary of model parameters employed.

Technical parameters	
Normal plant capacity	15,000 kW
Maximum system operation	8000 h yr^{-1}
Gross system heat rate	2.64 kWth kW^{-1}
Average plant heat use	12,240 kWth h^{-1}
Capacity factor	60–85%
Financial assumptions (*all values in CDN$*)	
Capital cost (supply, install, commission)	$ 3,850 kW^{-1}
Fixed operating and maintenance expenses	$ 150 kW^{-1} yr^{-1}
Variable operating and maintenance expenses	$ 0.009 kW^{-1} h^{-1}
Value of power sold under FIT to Ontario	$ 0.130–0.253 kW^{-1} h^{-1} (Table 2)
Value of natural gas displaced at the site	$ 0.013 kWth^{-1}
Value of heat sold	$ 0.000–0.013 kWth^{-1} (Table 3)
Biomass cost per tonne (delivered to site)	$ 49.50 per green tonne
Discount rate for net present value analysis	10%
Depreciation: portion of project eligible for class 43.2	80%
Corporate income tax rate	32%
Escalation rate on power sold	0.0%
Escalation rate on operating and maintenance expenses	3.0%

Table 2
Payback period, IRR and NPV at various FIT rates.

	60% capacity			85% capacity		
Feed-in tariff ($CDN/kWh)	$ 0.130	$ 0.185	$ 0.223	$0.130	$ 0.146	$ 0.172
Payback period (yr)	12.0	6.6	5	8.0	6.5	5.0
20 yr IRR (after-tax)	1%	10%	15%	7%	10%	15%
20 yr NPV (after-tax) (CDN$)	$ (23.5 M)	$–	$ 15.6 M	$ (9.4 M)	$ –	$ 15.3 M

Table 3
Payback period, IRR and NPV by various values for heat.

	60% capacity			85% capacity		
Feed-in tariff ($CDN/kWh)	$ 0.130	$ 0.130	$ 0.130	$0.130	$ 0.130	$ 0.130
Value for heat ($CDN/kWth)	$ 0.000	$ 0.013	$ 0.127	$ 0.000	$ 0.013	$ 0.029
Payback period (yr)	12.0	10.5	5	8.0	6.3	5.0
20 yr IRR (after-tax)	1%	3%	15%	7%	11%	15%
20 yr NPV (after-tax) (CDN$)	$ (23.5 M)	$ (19.4 M)	$ 15.4 M	$ (9.4 M)	$ 1.5 M	$ 14.9 M

15% or more. To achieve these metrics, a value for heat of CDN$ 0.029 kWth^{-1} is required at 85% capacity, and a value of CDN$ 0.127 kWth^{-1} is required at 60% capacity.

2.4.3. Impact of increasing FIT rates for electricity with a 'market' value for heat sold

As it is unlikely that rates for heat will be provided that are higher than the current value for natural gas, it is interesting to ask how high FIT rates must be to meet the economic performance criteria required if all additional heat can be sold for the market value of CDN$ 0.013 kWth^{-1}. At 85% capacity, a FIT rate of CDN$ 0.153 kW^{-1} h^{-1} coupled with the sale of additional heat would provide a simple payback of 5 yr, a 20 yr IRR of 15%, and a 20 yr NPV of CDN$ 14.9 million. At 60% capacity, a FIT rate of CDN$ 0.213/kWh would provide a simple payback of 5 yr, a 20 yr IRR of 15%, and a 20 yr NPV of CDN$ 15.5 million. This suggests that achieving 'market' values for heat could significantly reduce the need for intervention in electricity rates, but reinforces the fact that the most recently offered FIT rate was simply too low to attract industrial participation.

The question then becomes, why was the OPA biomass FIT rate so low? The two areas where the OPA analysis and this analysis seem to differ the most are fuel costs and payback periods.

2.4.4. Payback period

In our discussions with local businesses and investors, the common expectation for payback period was significantly shorter than budgeted within the OPA model – as little as 1–3 yr. As shown in Fig. 1, the relation between feed-in tariff and payback period is characterized by rapidly improving returns as the payback period drops below 5 yr, and thus to approach a 3 yr payback threshold requires significant increases to the tariff rate. Using an 85% capacity factor, the FIT rate must be as high as CDN$ 0.25 kW^{-1} h^{-1}; at a 60% capacity factor, the FIT rate needs to be about CDN$ 0.36 kW^{-1} h^{-1}. With a 'market' value for available thermal output, the required FIT rates are reduced to about CDN$ 0.22 kW^{-1} h^{-1} at 85% capacity, and $0.27 kW^{-1} h^{-1} at 60% capacity. With a FIT rate of CDN$ 0.45/KWh, the payback period drops to 2.1 and 1.4 yr for 60% and 85% capacity factors, respectively; at this point, the value for heat becomes relatively inconsequential to the overall financial performance. It should be noted that these values are in the same range with the CDN$ 0.347 kW^{-1} h^{-1} rate recently offered for solar photovoltaic ground-mounted electricity generation. It is worth remembering that solar PV facilities offer few opportunities for significant employment once the initial construction is complete.

A second difference between this analysis and the OPA analysis is the price of wood. The OPA calculated biomass costs as CDN$ 4.50 per million British thermal units (BTU) (Lensink, 2011), which translates to CDN$ 26.50/GT of feedstock. Biomass costs in this study are based on the current rates being paid in the Renfrew area for biomass, at CDN$ 49.50 GT^{-1}. The very significant difference in these prices is in transportation. If transportation costs are subtracted from current Renfrew biomass prices, the remainder is very close to the OPA estimate.

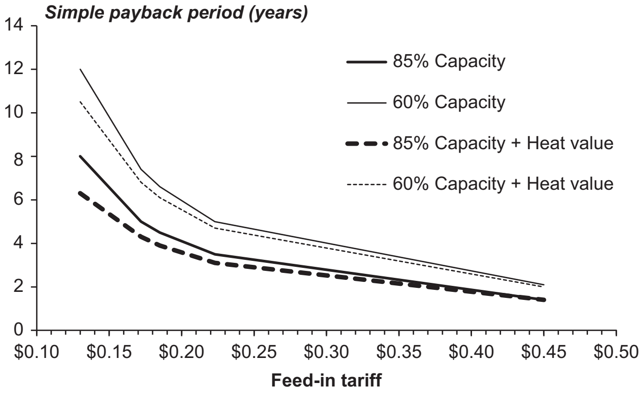

Fig. 1. Payback period by FIT rate for a 15 MW facility (60% and 85% capacity), with and without a value of $0.013 kWth^{-1} for heat outputs.

Transportation costs cannot be ignored. Biomass plants cannot be sited anywhere; they must be centrally located at a point where a grid connection can be made and that has sufficient space to handle the biomass required. That requires transporting the biomass fuel to the plant. As well, transportation costs are magnified as the plant scale increases because it takes more trucks burning fossil fuel to supply biomass to feed a larger plant. Indeed, as plants grow in size very real questions arise as to the sustainability of these operations, because of the increasing amount of fossil fuel (diesel and gasoline) required to facilitate movement of biomass to the facility.

3. Conclusions

Significant amounts of unused forest biomass that exist in the Province of Ontario could be used to generate electricity, which in turn could serve to maintain or increase employment in the forest sector while increasing the amount of dispatchable, renewable electricity within the market. To stimulate the use of forest biomass for electricity in the province, the incentive offered should reflect the true costs of production. The analysis presented here suggests that the feed-in tariff rate needs to be higher than the recently offered CDN$ 0.13 kW^{-1} h^{-1} for projects greater than 10 MW. It appears that in order to achieve a 15% IRR and a simple payback of approximately 5 yr, the corresponding FIT must be between CDN$ 0.17 kW^{-1} h^{-1} (at 85% capacity factors) and CDN$ 0.22 kW^{-1} h^{-1} (at 60% capacity factors). If all thermal outputs can be sold a rate approximately equal to current (March 2013) rates for natural gas ($0.013 kWth^{-1}), the FIT rates should be set between CDN$ 0.15 kW^{-1} h^{-1} at 85% capacity to CDN$ 0.21 kW^{-1} h^{-1} at 60% capacity. To achieve payback periods of 2 yr or less, as suggested by industrial proponents in Renfrew County, a FIT rate of approaching CDN$ 0.45 kW^{-1} h^{-1} would be required, although the model makes it clear that rapidly escalating FIT rates are required to decrease the payback period significantly beyond about 5 yr (both with and without a value for thermal outputs). Assigning higher FIT rates would provide recompense for transportation costs, which were not adequately addressed by the OPA's calculation for wood prices. Without stronger economic incentives, it is likely that biomass will be significantly under-used and will not contribute to the renewable energy goals of Ontario.

Concurrent with applying higher FIT rates, the analysis suggested that other policy barriers exist to the uptake of biomass-to-electricity projects in the province. It is recommended that Ontario consider following the lead of other jurisdictions and update operating engineers regulations such as Ontario Regulation 219/01. If Ontario were to implement modifications to this regulation similar to those which were introduced by the province of British Columbia, it would increase the ability of smaller enterprises to take advantage of biomass-to-electricity options.

This study illustrates the challenge of bringing different kinds of renewable energy projects online using a common incentive program. While the Ontario Power Authority made allowances for the cost of biomass when originally determining an appropriate feed-in tariff for biomass-to-electricity, it appears that these costs did not allow for the recovery and transport of the biomass from the forest to the mill. Under the recent Ontario FIT program, only the electricity component in a biomass facility was incentivized, with no bonus or additional income provided for the heat that is generated in these facilities. Other jurisdictions, notably Germany, provide incentives for the heat that allows biomass-to-electricity to better compete; a combined heat and power facility in Germany can currently qualify for a bonus above and beyond the base tariff rate of approximately €0.02 $kW^{-1}\,h^{-1}$ of electricity generated (approximately CDN$ 0.03 $kW^{-1}\,h^{-1}$) (Fulton et al., 2012; Mabee et al., 2012). Adding a similar bonus to the recent Ontario FIT rates would raise the offering for biomass-to-electricity and heat to CDN$ 0.16 $kW^{-1}\,h^{-1}$, which is very close to the minimum levels of incentive this study suggests. The best means of adding biomass-to-electricity to the Ontario renewable power portfolio would be to offer a higher FIT rate while at the same time finding means to better allow these facilities to utilize thermal outputs.

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